piezoelectric/electrostrictive film element in a manufacturing method of various film devices using the ceramics.

Considering the ultimately obtained film quality, methods mainly used for the ceramic sol solution are dip coating, spin coating, electrochemical oxidation/reduction etc. while methods used for the ceramic oxide powder are various printing, molding, electrophoretic deposition (EPD) etc.

Among these methods, EPD is a method to mold an elaborate film, ~~using~~ making use of the polarization of each component by electric polarity and the stacking property of solid particles.

In the EPD process using a ceramic oxide powder shown in block d. in Figure 2, ceramic particles of average diameter not less than 1 μm made by a solid phase process are dispersed in an adequate dispersion medium of water or organic dispersant. Then, they are mixed with a pH-controlling medium to make a sol solution controlled ~~of~~ in surface electric charge, which the colloidal suspension is used for ceramic to move to a cathode or anode to form a film on a substrate. ~~which~~ This film is vapor deposited by thermal treatment above 1000°C, eventually to form the film.

EPD like this has an advantage to make a high quality film unrestricted ~~of~~ in area or thickness using a simple equipment.

But ~~there needs~~ a separate operation is needed to disperse powder using a dispersant, in order to secure dispersibility, because a large particle diameter powder is used, ~~and~~ Also, there is inevitability a problem of high temperature thermal treatment to get material property peculiar ~~of~~ to the ceramic because the formed film property is similar to the bulk.

SUMMARY OF THE INVENTION

The present invention to solve the problems has purpose of ~~firstly~~ providing a ~~method to form~~ a piezoelectric/electrostrictive film element formed by ~~through~~ electrophoretic deposition and thermal treatment at low temperature using ultrafine ceramic oxide powder which is ~~very~~ excellent in reactivity ~~as well as it is~~ and has very fine ~~in~~ particle size as it has been made by a single process at low temperature by combustion method using ~~the~~ citric acid as a combustion aid ~~and of secondly the provision and supply of~~ piezoelectric/electrostrictive film element formed by the method ~~at low temperature~~.

The present invention to achieve the purpose provides ~~features~~ a ~~method for forming~~ piezoelectric/electrostrictive film element formed at low temperature using electrophoretic deposition, by the method comprising the steps of : preparing a solution or a dispersed mixture containing constituent ceramic elements by dissolving or dispersing the raw material of constituent ceramic elements in a solvent or a dispersion medium; preparing a mixed solution by adding citric acid into the solution or the dispersed mixture in which the constituent ceramic elements are dissolved or dispersed; getting ultrafine ceramic oxide powder of particle size less than 1 μm with uniform particle diameter size distribution by forming ceramic oxide without scattering over, by nonexplosive oxidative-reductive combustion reaction by thermally treating the mixed solution at 100-500°C; preparing a suspension by dispersing the ultrafine ceramic oxide powder in an organic dispersant; preparing ceramic sol solution by dissolving constituent ceramic elements of same or similar ~~constituent with~~ as the ultrafine ceramic oxide powder in water or

with the ceramic sol solution

an organic solvent; dispersing by mixing the suspension in which the ultrafine ceramic oxide powder is dispersed ~~with the ceramic sol solution;~~ forming a piezoelectric/electrostrictive film element by submerging a substrate into the suspension in which the ultrafine ceramic oxide powder and the ceramic sol solution are mixed and then ~~by~~ performing electrophoretic deposition; and thermally treating the piezoelectric/electrostrictive film element at 100-600°C , so that the solvent is removed by the thermal treatment and ~~the~~ bonding among the ultrafine ceramic oxide powder particles is induced while the ceramic sol acts as a reaction medium on the surfaces of the ceramic oxide particles.

Also the present invention features a piezoelectric/electrostrictive film element produced by a method comprising the steps of : preparing a solution or a dispersed mixture containing constituent ceramic elements by dissolving or dispersing the raw material of constituent ceramic elements in a solvent or dispersion medium; preparing a mixed solution by adding citric acid into the solution or the dispersed mixture in which the constituent ceramic elements are dissolved or dispersed; getting ultrafine ceramic oxide powder of particle size less than 1 μm with uniform particle diameter size distribution by forming ceramic oxide without scattering over, by a nonexplosive oxidative-reductive combustion reaction by thermally treating the mixed solution at 100-500°C ; preparing a suspension by dispersing the ultrafine ceramic oxide powder in an organic dispersant; preparing a ceramic sol solution by dissolving constituent ceramic elements of the same or similar